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TELECOMMUNICATIONS AND INFORMATION TECHNOLOGY IN LATIN AMERICA: PROSPECTS AND POSSIBILITIES FOR MANAGING THE TECHNOLOGY GAP**

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Abbreviations Used Throughout

DC	Developing Country
IAC	Industrially Advanced Country
IT	Information Technology
MNC	Multinational Corporation
PABX	Private Automatic Branch Exchange
PTT	Ministry or Administration in charge of Posts, Telegraph and Telephones
R&D	Research and Development
TC	Telecommunication

Also see glossary of technical terms.

INTRODUCTION

Within the now substantial body of literature concerning microelectronics and the trends towards information based technology (IT), little attention so far has been payed to telecommunications. This is quite surprising given a) the size and growth of the market, b) the importance of telecommucications (TCs) as infrastructure for IT, and c) the role of TCs as a 'leading edge' in the accumulation of capabilities in IT. Even within the studies concerning the industrially advanced countries (IACs) there is very little analysis of the infrastructural and cutting edge properties of TCs. Nevertheless several IAC governments are actively supporting their locally based manufacturing industries, in an effort to gain national advantages over their competitors in the rapidly growing IT markets.

This is a matter of grave concern for the developing countries (DCs) in their efforts to develop the necessary skills and technological capabilities to understand and use microelectronic technology. Without well orchestrated and informed policy responses to changes brought about by digital innovation there is a very real danger of the loss of international competitiveness, worsening comparative advantage, and exclusion from many information intensive economic activities. The main purpose of this paper is to examine the prospects for the Latin American region in gaining a 'foothold' in IT in view of the rapidly changing technological and economic environment worldwide. The question of whether specific DCs can use existing TC facilities and planned infrastructural investments as a cutting edge in IT development will require detailed country by country analysis. The aim here is therefore to provide a general assessment of the issues and to point to possible TC related strategies of managing the technology gap between Latin America and the IACs.

Part 1 begins by briefly discussing the stategic importance of TCs both as infrastructure for IT and as a leading edge in the accumulation of microelectronic capabilities. This section goes on to suggest that existing demand for digital TC facilities in the DCs could, potentially, be employed as a means for 'leapfrogging' intermediate forms of communications infrastructure, and for gaining vital capabilities in the broader area of IT. In order to assess the prospects for technology transfer and local development of TCs Part 2 examines the international market structure of the industry and the impact of digital technological diffusion accross

the major sub-sectors of the industry. It is argued that the process of microelectronic diffusion has opened up various 'technological opportunities' for entry by the DCs, in a number of important areas of the industry.

Part 3 broadly examines the current and forecasted market demand for the Latin American region and attempts to show that the very large market, and the planned adoption of fully digital TCs, does indeed present a potential for exploiting the leading edge properties of TCs. Finally Part 4 looks selectively at individual countries of the region and stresses the importance of differentiating clearly between economies of different overall size and different levels of economic and technological infrastructure. An effort is made to point to possible areas of mutually beneficial international collaboration especially for the smaller countries of the region. Ultimately though, much will depend on individual and cooperative government policy initiatives in successfully managing the technology gap.

(A glossary is also provided to define such terms as information technology, telecommunications, and other necessary technical terms.)

PART 1 THE STRATEGIC IMPORTANCE OF TELECOMMUNICATIONS IN THE DIFFUSION OF INFORMATION TECHNOLOGY.

1.1 Telecommunications as IT infrastructure and a 'leading edge' in the accumulation of technological capacity.

There now exists a substantial body of literature regarding the diffusion of microelectronic, information-based technology. (See Forester 1980, Bessant et al 1981, and Leppan 1983, for reviews). Two of the most widespread findings concerning the IAC's are first, the rapid rate of diffusion of micro technology, and second, the astonishing pervasion covering virtually all economic sectors. For example a study conducted by the OECD (1981) shows that, broadly defined, information-based occupations now constitute the largest share of employment in the majority of the OECD countries, and is providing the fastest rates of employment growth in the IAC's. In spite of severe economic recession the sales of IT products have continued unabated (Rothwell 1984). The extent and speed of IT diffusion as well as implications for employment and output growth are subjects comprehensively studied in the IAC literature. What is not nearly so well covered is the role and importance of telecommunications in the shift towards IT.

When one considers the size and role of the TC sector this is indeed surprising. Overall TC activities in the EEC, the USA and Japan, represent around 3% of GDP which places the dimensions of the industry on roughly the same footing as the largest industries worldwide (eg.the motor vehicle industry, electricity supply, aerospace and chemicals). As a consequence of continued rapid growth TC activities are expected to reach about 4.4% of GDP by 1990, and by the year 2000 will surpass the other largest industrial sectors forming approximately 7% of total GDP. Also the closely related telematics sector, based on the convergence of digital TCs with computer technology, will probably match the overall dimensions of TCs by the early 1990's (A.D. Little).

As mentioned above TCs are also playing a fundamental role in the shift towards digital, information based activities.

First, as basic infrastructure for IT telecommunications actually represent a determining constraint on the diffusion of informatics and telematics technologies. Second, TCs are proving extremely important in national efforts to accumulate capabilities in IT. Again, the scant attention paid to TCs from these perspectives is a matter of urgent concern. It is now common policy practice for governments in the IACs to exploit the cutting edge properties of TCs in order to help ensure their relative international positions as IT diffusion proceeds. This is carried out principally through investment programmes or support to national TC equipment manufacturers (Bessant 1983), and by legislation to promote increased competition in the introduction of new IT services. (Note the recent anti-monopoly legislation in the USA and UK).

As infrastructure for IT the role of TCs is made all the more important especially when one considers the various forecasts concerning the next sustained economic upswing, widely suggested to be based on, or certainly led by microelectronic IT diffusion. As Barron and Curnow (1979) argue in their assessment of the UK position:

> "The major obstacle to the development of the information society will be the provision of adequate telecommunications capability..... From a national point of view the greatest leverage might be obtained by an active programme of investment in an advanced telcommunications system. This would provide the infrastructure for an information society and would generate a positive market for the information technology industry in the U.K.".
>
> (Pages 18 and 20)

In terms of the developing countries it is crucial that appropriate policy responses are designed to meet the challenges posed by digital information technology, not only to prevent a widening of the technology gap, but also to gain any possible advantages from the technology. A failure to respond to these changes may well threaten a shift in comparative advantage away from the DCs, and the exclusion from many IT activities.

1.2 Microelectronics, telecommunications and the developing countries - a possibility of managing the technology gap.

If we turn to the literature regarding microelectronics and the developing countries even less attention has been paid to TCs. While a great deal of study has been invested in the general role of TCs in economic development (Hobday 1982 provides a review), there is no empirical study of the potential role of TCs as information technology infrastructure, or as a means of gaining vital skills and knowhow in digital technology.

Most study of microelectronic diffusion and the DCs has been confined to a very narrow range of industrial technologies, and an even narrower range of process technologies across sectors such as CAD and software applications (reviewed by Leppan 1983). The primary concern of most observers is the possible negative economic implications of microelectronic diffusion and the difficulties facing DCs in acquiring such an advanced form of technology (Rada 1982, Kaplinsky 1982). Among the main economic concerns are 1) the possibility of erosion of comparative advantage of the more advanced DCs. The argument holds that existing comparative advantage based on cheap labour may be eroded as automation technology makes it both technologically feasible and more profitable for MNCs to relocate production facilities in the IACs. 2) The possibility of a new and harmful phase of emerging DC technological dependency on the IACs and especially the multinational suppliers of equipment and technology. 3) The inappropriateness of digital technology both in terms of skills and factor endowment, especially in view of the labour-saving nature of the technology and the sophisticated knowhow required in its manufacture and application.

More recently though there have been indications that the early widespread pessimism may have been overemphasised. The rate of conversion to fully automated digital systems is both slow and uneven in the IAC's, and relocation to the north has not proceeded as expected (Bessant 1983, Leppan 1983). Indeed there may well be a 'breathing space' for DCs to assess

their positions and organise strategic responses to the challenges posed by microelectronics (Perez 1984).

In terms of the labour saving nature of electronic technology, research by Soete and Dosi (1983) shows that the technology is also capital saving and this may prove beneficial in overcoming capital constraints in DCs. As far as skills are concerned, although traditional means of acquiring mechanical and electromechanical technologies (eg. learning-by-undoing or reverse engineering) may not be suitable for IT, other information-based learning mechanisms may be available (Hobday 1985 part 3.3). In fact a number of the larger DCs including India and Brazil have already established fairly sophisticated capabilities in software and CAD technology. The shift to information-based, digital technology may actually assist in overcoming the common DC bottleneck problems in fine engineering and electromechanical interfacing. Indeed many of the larger DC are well endowed with high level information and design skills at universities and other research centres.

The very narrow base of empirical research in this area means that generalisation across economic sectors is not yet possible. Nevertheless recent study does suggest that well-informed and pragmatic policy intervention may assist in overcoming the difficulties faced in the acquisition and use of digital technology. Rather than passively accepting any potentially harmful consequences of microelectronic diffusion, DCs may be in a position to by-pass or 'leapfrog' older, less efficient forms of technology and move directly to more flexible and lower cost digital technology (Soete 1984). By strategically gaining the necessary skills and knowhow many DCs may be in a position to effectively manage the technology gap. Certainly in TCs this appears to be the case as discussed below.

However, in order to assess the prospects for DCs in the overall area of IT it is imperative to distinguish clearly between a) DCs of different market sizes and levels of technological infrastructure, and b) the specific sector undergoing digital innovation. As the various case studies show

(Jacobsson and Sigurdson 1983 provide a collection of papers), the pattern, rates and effects of microelectronic innovation vary considerably according to the sector under discussion and in particular, the 'information intensity' of the sector. Rates of diffusion have been highest in information related products and processes such as computing, data processing and TCs. In traditional manufacturing sectors diffusion has been considerably slower and the impacts less dramatic partly due to the heavy existing investments in previous forms of technology.

It is also vital to distinguish between DCs at different levels of economic and technological development, as the opportunities for aquiring and developing digital technology will depend very much on existing infrastructure. So too, market size will be an important variable in determining an appropriate level of manufacturing and technological capacity for the economy. Before examining these issues in the context of Latin America it is first necessary to analyse the changing international market structure in TCs as this too will exert a considerable influence on the general prospects for technology transfer and local development by the DCs.

PART 2 THE CHANGING INTERNATIONAL MARKET STRUCTURE IN TCs AND THE IMPLICATIONS FOR DEVELOPING COUNTRIES

The diffusion of microelectronic technology throughout the TC industry has dramatically altered both the size of the industry and the international competitive environment. Digital innovation and the convergence with other IT based industries has given rise to many new entrants to the market and profoundly changed the nature of the products and processes involved in TC manufacturing. This rapidly changing technological and economic environment has, not surprisingly, radically affected the prospects for DC's in their efforts to transfer technology and develop products and processes locally. To help assess the implications of these changes it is useful to begin by outlining the structure of the industry.

2.1 Microelectronic diffusion, market growth and competition.

Table 1 presents worldwide sales of TCs by major product lines for 1980 and 1985.

Table 1 Shares of Major Telecommunications Product Lines in World Sales 1980-1985 (estimated).

	Value of World Sales ($billions)		% of Total	
	1980	1985	1980	1985
Switching	12.6	18.4	31.9	31.7
Transmission	12.2	17.4	31.0	30.0
Terminals	5.8	8.0	14.7	13.8
Private Systems	4.3	6.4	10.9	11.0
Mobile Radio	3.8	4.9	9.6	8.5
Other	0.7	2.9	1.8	5.0
Totals	39.4	58.0	100	100

Source OECD 1983 p20 (amended) assumed to be constant prices.

In 1980 total product sales stood at just under $40 billion and by 1985 will reach $58 billion. While growth estimates

vary there is general agreement that rapid growth will continue throughout the industry during the '80s and the '90s. Arthur D. Little for example estimates that the annual average growth of roughly 8.5% during the early '80s will only slow slightly to 8.0% in the latter half of the '80s. And this is despite forecasts of continuing economic recession.

Switching or exchange equipment constitutes nearly 32% of the overall market. This equipment represents the heart of public and private TC systems,switching messages within and between networks. Transmission systems rank alongside exchange equipment with 30% of the market. Transmission systems are responsible for sending information, now usually in digital format, from one geographical location to another. The balance (or peripheral equipment) includes all other devices involved in forming a TC network and includes terminals, telephone handsets, modems and other input/output devices. The above data do not, unfortunately,seperate out the rapidly growing private exchange market (PABXs). PABX's now represent one of the most dynamic areas of the market with the shift towards digital technology and more private applications.

Throughout the '70s and into the '80s digital technology has had a profound affect on the market structure of the industry. What was once a stable, oligopolistic industry has been transformed into a highly competitive, rapidly growing and changing market. In many areas a great deal of uncertainty surrounds the prospects for existing suppliers. As the technological base of the IT industries in computing, informatics, telematics and some areas of consumer electronics converge around digital technology new competitors have entered the TC industry. As new manufacturers enter, the stable position of many of the traditional suppliers is being threatened.

Part 1 argued that the effects of microelectronic innovation need to be examined on a sector by sector basis. Even within the TC sector there are conflicting and complex trends which have a direct bearing on the prospects for DCs attempting to acquire and develop the technology. It is therefore necessary to examine the likely impact of these changes in

terms of the three main subsectors - exchange, transmission and peripheral equipment.

2.1.1 Exchange Technology.

In the exchange sub-sector massive R&D investments have led to fully automatic, stored programme controlled, solid-state digital exchanges. The generally accepted superiority of these systems is leading to the gradual replacement of less efficient, less flexible and more costly electromechanical exchanges. In the DCs there exists a very real possibility of by-passing or 'leapfrogging' older vintage technologies and moving directly to fully digital technology. In terms of communications infrastructure this represents a great benefit to DCs who, typically, will pay three to five times less (for installing say 1 million lines) than the now developed economies did 30 to 40 years ago (Jequier 1977). The most modern fully digital exchanges are today roughly one half of the price of equivalent electronic analogue and electromechanical public exchanges (Saunders et al 1983). Most DCs are in the attractive position of installing and expanding their basic TC networks, while the IACs are generally heavily committed to less efficient, lower capacity, previous technological forms. At the level of IT infrastructure DCs potentially have an advantage over the IACs now faced with the daunting task of replacing inappropriate infrastructure and the enormous economics of scrapping problem this entails.

These leapfrogging advantages in terms of the use of the technology apply equally to transmission and peripheral equipment, where there is no doubt that digital diffusion has radically impoved the cost/performance ratio of existing electromechanical systems - as well as introducing a wide range of new applications. However, in terms of the manufacture of the systems and the development of the technology, at first sight the shift to digital switching appears to pose very severe financial and technological barriers to entry for DCs.

R&D investment costs in public exchanges reach staggering proportions, with estimates ranging from $400 million

up to $1 billion for the major public exchange systems. These huge R&D thresholds have acted to prevent entry from other closely related industries, and there is very little chance of even the largest computer manufacturers entering the competition in the near future. As well as financial barriers there are very substantial technological barriers to entry. Very complex, TC specific software is required to develop exchange systems and this has proved a major difficulty even for experienced TC manufacturers.

Microelectronic diffusion has generated fierce technology based competition among the existing international suppliers. There are currently 16 major systems in the market developed at a cost of over $6 billions competing for annual uncommitted export markets of only $2-to $3 billions. This degree of market saturation will probably mean that some of the systems will not realise a positive return on investment (OECD 1982).

At first sight these very daunting financial and technological barriers to entry would indicate very poor prospects for DCs wishing to aquire and develop exchange technology. However this may not be the case for three main reasons. First, the fierce international competition has placed the DCs in a very good bargaining position and they are able to obtain the systems at very low prices. PTTs in the DCs can often buy the latest equipment on better terms than users in the developed countries, who are often contractually obliged to financially support local manufacturers. Many of the large R&D investments are justified in terms of export markets and it is in the DCs where the largest non committed export markets lie. Hence the increasing importance attatched to third world markets.

Second, when sales of equipment are linked to setting up manufacturing and technological facilities the open bidding for orders is even more intense as the financial stakes are that much higher. The competition for the recent Indian contract testifies to this. Ten major suppliers competed and eventually the well established French system won the orders. However, in order to win, the French government was obliged to

step in and offer an 'aid for trade' cheap loan arrangement and full technological training by French scientists. A similar situation also appears to be emerging with the Chinese plans to upgrade and expand the TC infrastructure of the industrial Yangtze Delta region.

A third potential benefit from the shift to digital technology relates to the modular nature of exchange systems and the opportunities for entry in smaller scale private and public exchanges. The PABX market has witnessed rapid growth in small private exchanges. In this very dynamic sector of the market the software is much less complex and many new manufacturers have entered from the computer and office equipment markets. In the USA in 1961 there were only 4 PABX manufacturers, by 1980 there were more than 30, and in terms of terminal equipment overall there are now over 1000 approved local manufactures (OECD 1983). Furthermore, the modular nature of digital technology means that it is now possible to gradually develop and acquire capabilities even in public exchanges. Brazil, for example, has developed and manufactured locally small exchanges of roughly 1000 lines for use in rural areas. They are also planning to build on the experience gained in software and hardware technology to gradually move up the scale of technological complexity onto larger public exchanges. The tendency towards greater modularity reflects a higher degree of capital and technological divisibility and this is a direct consequence of microelectronic innovations. (The implications of the shift away from the highly 'verticalised' manufacturing technology towards digital 'horizontalised' technology is discussed below in section 2.2).

To summarise, despite the substantial barriers to entry in exchange systems there may well be 'points of entry' for DCs as a result of the diffusion of digital technology. The exploitation of any potential technological opportunities will depend very much on the size of the domestic market and level of scientific and technological infrastructure, as well as effective domestic government policies towards TCs.

2.1.2 The Transmission Sector

In the transmission sub-sector a similar pattern of increasing competition within the industry has emerged as a result of digital innovation. However, the much lower degree of technological complexity and lower financial barriers to entry have given rise to many new entrants to this sector, principally from the technologically convergent areas of radio and aerospace manufacturing. The traditional dominance of the coaxial cable manufacturers has given way to microwave system producers, and both of these transmission mediums have benefited greatly from digital PCM and TDM techniques. As with exchange systems cost/performance ratios have improved dramatically. Miniturisation with micro technology has made satellite communications economically viable and the use of satellites is growing rapidly in both private and public communication networks. In recent years digital innovation has resulted in falling communication costs in the region of 11% per annum in terrestial systems. With satellite communications cost reductions have averaged roughly 40% per annum per data/speech channel (Muller 1982).

Fibre optic technology also boasts considerable advantages over traditional systems in terms of greater capacity, speed, flexibility, resistance to interference and significantly reduced installation costs. As technical difficulties are being overcome and the technological and economic superiority of fibre optics, over traditional systems, is gradually being accepted, they are forecast to diffuse far more rapidly in the latter half of the '80s and throughout the '90s.

As far as the DCs are concerned the move towards digital technology again holds good prospects both in the use and the production of the equipment locally. By by-passing intermediate technologies the DCs are in a position to avoid more costly and less efficient transmission methods and move directly to digital IT infrastructure. Modern digital systems are not only far less costly but can also simultaneously transmit voice, data, text, TV and various other forms of

information using the same hardware.

In terms of entry into production, the relatively low barriers to entry indicate that there may well be opportunities for DCs, especially the larger economies, to locally manufacture and develop systems. Local Brazilian firms for example, are already designing and manufacturing digital PCM and TDM equipment to supply the local market. Brazil has also developed a fibre optic transmission system and will be producing in volume for the local market this year (Hobday 1985). Brazil, of course, is a relatively large economy among the DCs, with a well developed scientific and technological base; however there may well be opportunities for smaller DCs to begin manufacture and gain the 'leading edge' advantages of direct experience in developing the technology.

2.1.3 Peripheral Equipment

Turning to peripheral equipment, market entry opportunities for DCs are probably greatest in this rapidly growing sub-sector. As a consequence of digital diffusion the manufacturing processes and the products themselves have converged with several other industries experiencing microelectronic innovation. The 'merger' of the computer and TCs industries, based on semiconductor technology, has given rise to market entry not only from traditional computer firms, but also the office equipment industry and even some areas of the consumer electronics industry. The economic attraction of digital technology is again, far greater capacity, speed, flexibility, a much wider range of functions and an overall improvement in cost/performance ratios - as compared with electromechanical analogue equipment.

Here again the traditional market boundaries are being radically redefined, competition is increasing, and equipment prices are in general, falling. Digital technology has created a far larger market and in spite of economic recession many new products and applications are recording increasing sales.

It is in the peripheral sub-sector that the barriers to entry are lowest in TCs. Consequently there is a growing

range of technological opportunities for entry by DCs in many important areas such as intelligent terminals, modem and codec equipment, key systems, mobile radio, visual display units etc. The very rapidly growing PABX market is also sometimes included in this sector.

2.2 The 'technological divisibility' of digital TCs - new opportunities for Developing Countries.

In order to understand the overall prospects for DCs in view of the rapidly changing technology it is helpful to explain in more depth the nature of digital technology in contrast to electromechanical technology. Hopefully an analysis of how 'digitalisation' has transformed TC products and processes will shed further light on the opportunities facing DCs.

As noted earlier digital technology is intrinsically modular which means that a system is comprised of a range of independent but compatable modules which together form the TC network. Put another way digital systems are 'horizontalized' in the sense that various independent components form the building blocks of an expandable system. So too in the manufacturing process microelectronic components constitute the building blocks of the product and resemble more and more the final good itself. This is in sharp contrast to electromechanical technology. Here, there is a high degree of vertical integration in the production process with a large number of specialised TC component inputs such as relays, screws and connectors. Under the 'verticalized' electromechanical technology most of the component parts are manufactured by the TC manufacturers themselves and the skills and knowhow required in production are very specific to TCs. Indeed a thoroughgoing engineering capacity is required in virually all stages of component production, testing, manufacture, installation and maintenance. The actual manufacture of electromechancial crossbar systems is a far more complex process than with digital technology and large numbers of engineers and technicians are needed especially in fine engineering and electromechanical interfacing.

In constrast, the modular 'horizontalized' nature of digital technology requires far less engineering in manufacturing,which resembles a simpler assembly process. A large proportion of the microelectronic components are bought in from semiconductor manufacturers outside the TC industry itself. (Material input costs, now primarily semi-conductors, have risen to an estimated 70% of total direct costs in 1978, from only 20% in 1965, OECD 1983 p57). The horizontal nature of digital technology implies a far higher degree of capital and technological divisibility. Capital divisibility implies more opportunities for smaller scale investments in specialised product areas - this is the case even in the highly complex exchange systems. The concept of 'technological divisibility'is also extremely useful in this context. The technological divisibility of digital TCs means that it is possible to select a specific product area and master the design and production process. In this manner skills can be gradually learned and accumulated as firms move upwards towards more complex products and systems.

Although it is not possible here to discuss these technological issues in detail it is plain to see how digital technology has both radically transformed the international market structure in TCs, and provided opportunities for DCs to enter the previously guarded market. Digital diffusion has acted to break down the electromechanical oligopoly which characterised the industry for many years. The oligopoly of the TC suppliers was closely associated with the vertically integrated production process, in-house component suppliers, and TC specific engineering skills. As the diffusion of digital technology occurred the products not only became far cheaper and generally superior, but also many new competitors were capable of entering the industry. The technological convergence of a 'cluster' of industries based on digital information technology allowed entry from the computer, aerospace, office equipment and other, traditionally seperate, industies. Although the traditional manufacturers still dominate the large-scale public exchange market, this represents a declining share of the total TC industry and in PABXs,

transmission and peripheral technologies new competitors are seriously challenging the traditional suppliers.

Indeed this process of 'technological convergence' around semiconductor digital technology is one of the striking features of the information technology industry. Conceptually this can be viewed as an acceleration of the process of technological convergence during the 19th and 20th centuries described by Rosenberg (1976, pp 156-157) where many previously unrelated products in terms of nature and use became closely related on a manufacturing technology basis. This process of technological convergence not only applies to IT finished products and their manufacturing processes, but also to the production of the microelectronic building blocks of the IT industry. It is remarkable that semiconductor components covering such widely diverse applications as consumer, computer and military industries, are all manufactured in basically the same way.

As far as the DCs are concerned this process of digitalisation presents several important opportunities for market entry. Under electromechanical technology a thoroughgoing engineering capacity was required throughout the development, manufacture and even operation and maintenance of the networks. This both supported the stability of the industry and prevented entry by DC as well as IAC firms. With digital technology far fewer engineering skills are required. A small range of high level information-based design skills, coupled with a much wider range of simple assembly and testing skills are needed. This process of skill polarisation is a common feature of the IT industry.

Given a supply of these information-based design skills DCs are in a good position to enter the manufacture of several important areas of the TC industry and IT in general. Following design and development the manufacturing process itself is a relatively simple, assembly type operation requiring far fewer engineering and technical expertise. In operation and maintenance there is also a dramatic reduction in the numbers of engineers and technicians needed. Rather than being an obstacle to DC entry, skill polarisation under digital

IT may assist in overcoming existing skill bottlenecks especially in fine engineering and electromechanical interfacing. The move to digital technology could potentially allow the application of existing research and university resources more directly to the design and development of local products in telecommunications. In fact the convergence around semiconductor technology cuts both ways not only allowing other industries to enter TC production, but also TC producers to enter other areas of IT. In the following an effort will be made to identify possible TC led strategies to exploit these potential technological opportunities.

PART 3 TELECOMMUNICATIONS IN LATIN AMERICA - CURRENT DEMAND AND IMPORT SUBSTITUTION POSSIBILITIES.

The previous sections attempted to show that, potentially at least, there are very real possibilities for entry or import-substitution in TCs as a result of the shift to digital technology. The aim of this section is to examine the dimensions and growth of the Latin American TC market. An attempt is made to illustrate: first, the large overall size of the TC market; second, the general trend towards fully digital TCs and third, the centralisation of TC planning and purchasing under government administrations. Overall there appears to be considerable potential for Latin American countries to both 'leap-frog' older forms of communications infrastructure, and to use TCs as a leading edge in developing an IT industrial base for the region. In successfully exploiting any technological opportunities much will depend on coordinated and deliberate government policy both at the national and regional level. Part 4 looks in more detail at some of the individual countries of the region to identify possible TC led strategies of IT development.

Table 2 overleaf presents selected telecommunications and economic data for the major countries of the region, and as can be seen,country variations in terms of population and economic size are reflected in existing infrastructure. Although these data are now somewhat out of date they clearly illustrate the wide variations in installed infrastructure accross countries. Brazil, Mexico and Argentina are at the top end of the scale with several millions of telephone lines and countries such as Bolivia and Ecuador are at the lower end with installations in the hundreds of thousands.

GNP per capita broadly corresponds to telephone density reflecting the well established correlation between TCs and economic development indicators (Saunders et al. 1983 Chapter 4). Countries with relatively high per capita incomes such as Venezuela, Argentina and Costa Rica also register high telephone densities. Conversely, poorer countries such as

Table 2 Selected Telecommunications and Economic Indicators - Latin America circa 1980.

Country	Total Telephone Lines '000s	Total Telex Subscribers	Telephone Density Per 100 population	Total Population Millions	GNP per capita Income ($1979)
Argentina	1850	5000	10.3	27.0	2210
Bolivia	127	330	2.6	5.0	550
Brazil	4000	28000	6.3	115.0	1770
Chile	380	2000	5.0	11.0	1890
Colombia	1250	3400	6.0	30:0	1060
Costa Rica	112	800	10.4	2.3	1630
Dominican Rpblc.	110	900	n/a	6.0	n/a
Ecuador	220	1500	3.2	8.3	1110
Mexico	2520	8700	7.5	70.0	1880
Peru	232	2000	2.8	17.7	850
Venezuela	750	8000	8.6	14.1	3440
Sub Totals	11550	60600			
Other (17 Countries)	1280	8200			
Totals	12830	68800			

Sources: A.D.Little, Saunders et al (1983)

Bolivia, Peru and Euador register both low incomes per capita and low telephone densities.

As a result of the poor overall condition of much of the existing infrastructure in many of the countries of Latin America, systems are often subject to overloading at peak periods, and there is a general problem of unreliability and technical incompatability across countries. Furthermore in most countries there are large unmet demands for telephones, both registered and unregistered. These problems have led most Latin American countries to establish overall government owned or controlled operating service companies. By centralising TCs under one government entity it is possible to plan the expansion of existing networks and to introduce new technology systematically.

To understand the scope for import substitution and local production overall it is helpful to examine the current and forecasted equipment markets by value across countries. As table 3 below demonstrates, total TC demand for the region is estimated to have grown from $1.2 billion in 1980 to $1.8 billion in 1985, and then forecast to reach $2.4 billion in 1990. (All data unless otherwise stated are from A.D. Little Inc.) This represents a doubling of the market over the 1980s.

Overall the current market size represents appx. 3% of the total world market and while this appears very small, it can be misleading as Latin America represents an extremely important segment of the world market. Although the market represents only 3% of total world sales, in terms of digital public switching Latin America accounts for 16.3% of sales which compares with say 27.3% for Europe and 28% for the USA. As noted earlier sales to uncommitted third world markets are extremely important to the major multinational suppliers and Latin America represents a major and growing share of these sales. Equipment sales for the region are over 3 times the total for Africa, one and a half times Oceana, and far larger than less developed Asia. Regional plans for installing digital technology increases the importance of the Latin American market

Table 3 Telecommunications Equipment Markets in the Latin American Region. (Millions of dollars)[1]

A) Total Market	1980	1985	1990	Annual Average Growth % 1980-85	1986-90
Argentina	116.0	162.3	226.1	6.9	7.0
Bolivia	11.0	15.5	22.2	7.7	7.0
Brazil	474.6	713.3	868.3	8.5	4.0
Chile	25.9	42.1	61.4	10.2	8.0
Colombia	68.4	105.2	147.5	9.0	7.0
Costa Rica	18.2	24.1	29.4	5.8	4.0
Dominican Rpblc.	6.5	9.3	13.7	7.4	8.0
Ecuador	11.2	17.4	24.5	9.2	7.0
Mexico	175.6	285.5	430.9	10.2	9.0
Peru	21.5	41.0	81.5	13.8	15.0
Venezuela	97.1	188.1	248.3	14.1	5.0
Other Countries	146.7	200.5	236.9	6.5	3.0
Grand Total	1172.7	1804.3	2390.7	9.0	6.0
B) System Market					
Telephone	978.0	1524.1	2010.4	9.3	6.0
Telex, Telegraph and data	104.9	144.3	186.4	6.6	5.0
Satellite Comms.	14.2	14.6	34.0	0.6	18.0
Mobile Radio	70.4	111.9	145.3	9.7	5.0
Radio Paging	3.5	6.8	10.6	14.2	9.0
Cable TV	1.7	2.6	4.0	8.9	9.0
Grand Total	1172.7	1804.3	2390.7	9.0	6.0

1 Constant 1979 dollars

Source A.D. Little Inc.

and MNC competition within the region is expected to be very intense throughout the '80s.

Growth rates are expected to fall from an annual average of 9.0% over the 1980-85 period to around 6% p.a. over 1986-90. The estimated fall off in growth is partly due to assumptions regarding the Brazilian market which represents around 40% of the overall total, and also due to the fact that the starting base in 1985 is that much higher. The five largest markets, Brazil, Mexico, Argentina, Colombia and Venezuela represent around 80% of the Latin American market. The top 11 countries listed above constitute about 90% of the total equipment market and account for roughly 90% of all installed infrastructure in the region.

Part B of table 3 gives a breakdown of equipment sales within the TC sector. As in other regions the telephone market overwhelmingly dominates, accounting for roughly 83% of total demand. Within the telephone market the shares as between switching, transmission and peripheral equipment are not significantly different from international shares as discussed in part 2.1 above. In keeping with international trends the PABX market is expected to continue to grow rapidly. The balance of the market is largely accounted for by telegraph, telex, data transmission, mobile radio and radio telephone equipment.

Turning to technological trends within the region, while the pace of technological change is very uneven as between countries there is a general shift towards fully digital stored programme controlled (SPC) public switching. Recognition of the clear superiority of fully digital over previous systems has led most countries to establish plans to expand networks using digital technology. Brazil, Mexico, Argentina, Chile, Colombia and Peru have all begun the process of planning and contracting for SPC equipment. Some of the smaller countries of the region (in terms of TC market size) such as Ecuador and Bolivia are proceeding much more slowly towards fully electronic technology.

As far as transmission equipment is concered there are general plans for the upgrading of old paper insulated underground cables, and the diffusion of digital PCM and TDM systems is expected to continue rapidly. In terms of microwave transmission there is a slow move towards digitally modulated systems, and more digital satellite transmission will be adopted throughout the '80s and the '90s. In the PABX and peripheral market new demand is generally for digital equipment due to its economic and technical superiority, and there is a growing demand for equipment such as mobile radio and key systems, modems etc. Most of the larger economies are also expanding digital data transmission and telex facilities.

An important area of concern which should be mentioned here is the overwhelming focus of most planning for urban TC expansion and the danger that the rural areas will lag seriously behind. The greater demand for urban TCs and the higher levels of profitability in comparison with the rural sector has led to the concentration of investment in the major industrial centres. Despite some projects for rural expansion in several Latin American countries such as Costa Rica and Brazil and a number of rural TC cooperatives, rural TC expansion remains very much a second priority. This partly reflects the deeper poverty in the rural areas and the generally superior infrastructural developments in the urban sectors. Nevertheless without sufficient attention to rural telecommunications planning, there remains a very real long-term threat to agricultural efficiency, regional integration, and further urban/rural inequality.

Returning to the issue of market trends most of the Latin American market is supplied by the major international corporations or their subsidiaries located in the various countries. Table 4 provides details of the major suppliers, by country, in rough order of importance for the switching equipment market. With the shift to digital technology Japanese firms such as NEC, Oki and Hitachi are challenging the traditionally dominant European and US firms. The traditional suppliers, ITT, Ericsson and Siemens are also being challenged by Japanese

Table 4 Leading Suppliers of Telephone Exchange Equipment in Latin America.

Country	Principal Suppliers in Approximate Order of Importance.
Brazil	Ericsson, ITT, NEC, Siemens
Mexico	ITT, Ericsson
Argentina	ITT, Siemens, Ericsson, NEC.
Colombia	Ericsson, ITT, Siemens
Venezuela	Ericsson, ITT, Hitachi
Chile	ITT, NEC
Peru	ITT, Philips
Ecuador	Ericsson
Bolivia	Oki, Ericcson
Costa Rica	Ericsson, ITT, GTE
Dominican Rpblc.	GTE

Source: A.D. Little Inc.

firms in the transmission and peripheral equipment markets.

Additional pressures towards increasing competition are arising from the trend towards centralisation of TC organisation and planning under government administration. This has enabled the larger DCs notably Brazil, Mexico and Argentina, to insist that manufacturing and in some cases technological facilities are located within national boundaries. In effect the governments monopsony purchasing power is being used as a strategic means of aquiring local production facilities and increasing the competition among the suppliers who are obliged to comply to gain orders and remain in the market. This is a position very peculiar to TCs and does not apply to other areas of IT, for example in computer and office equipment sales, where purchasing is distributed across government, industry, and mass market sectors. This again strengthens the argument for using the TC sector as a major leading edge in the accumulation of digital technology for the DCs.

In summary the above analysis indicates that there exists a real potential for Latin America to employ TCs as a leading edge in the aquisition of a base in digital technology, and indeed to gain the advantages of leapfrogging earlier forms of infrastructure. Latin America represents a large and rapidly growing market experiencing a general shift towards digital technology. The centralisation of TC purchasing in government hands allows the possibility of import-substitution by local firms, and local government to insist that a greater level of manufacturing by the MNCs is actually located within national boundaries. However for the individual countries of the region much will depend on local market size and possibilities of regional collaboration. In addition coordinated national and regional policies will also be a determining factor in establishing a manufacturing and technological base in IT. The following attempts to highlight the considerable variations accross individual countries and attempts to identify possibilities for market entry.

PART 4 A PRELIMINARY SURVEY OF LOCAL TC DEVELOPMENTS AND PROSPECTS FOR REGIONAL COLLABORATION.

The aim of this section is to provide a brief survey of the major countries of the region and to point to areas of possible international collaboration, especially among smaller countries. A great deal of further research is needed in this area and here it is only possible to selectively discuss the general status of local manufacturing and technological achievements for the larger markets of the region. Several of the economies of Latin America already possess a surprisingly strong capacity in telecommunications technology and an effort is made to identify possible strategies of TC-led information technology development. Recent experiences of international cooperation within for example, the Andean and Central American sub regions suggest that although there is a strong impetus to coordinate TC planning internationally, there exists far greater scope for these kinds of efforts especially in the area of technological collaboration.

In terms of telecommunications demand the four largest countries of the region, Brazil, Mexico, Argentina and Venezuela represent around 75% of total TC sales. It is useful therefore to briefly discuss each of these countries in turn.

4.1 Brazil

Within Latin America Brazil stands out as an example of how, through coordinated government policy initiatives, rapid infrastructural developments can be achieved in conjunction with domestic industrial and technological progress. A detailed analysis of Brazil's remarkable achievements in this area is presented elsewhere (Hobday 1985). Here it is helpful to briefly outline: a) Brazil's strategy of technological accumulation in digital TCs, and b) the developing linkages between TCs and broader IT. These two facets of the Brazilian TC industry hold valuable insights for other Latin American countries wishing to follow a similar path in establishing a national base in digital technology.

In the early '70s Brazil set itself two main objectives - to build a modern, efficient TC infrastructure and to establish a thoroughgoing industrial base in TC technology (the decision to acquire fully digital technology took place as early as 1976). To achieve these complementary aims the ministry of communications set up an R&D centre in TCs (CPqD) under the overall operating company Telebras. The centre was responsible for mastering all main areas of digital technology in TCs. At the same time all regional purchasing was centralised under Telebras and this substantial monopsony power was to be used to insist that the MNC subsidiaries located more manufacturing and technological facilities within the national boundaries, and where possible to foster the development of new Brazilian firms. CPqD also played a major role in this respect. The gradual accumulation of knowhow and technical expertise gave Brazil an improved bargaining position in relation to the MNCs and ensured a greater degree of technological integration of the subsidiaries. In addition the centre was responsible for assessing local firms' capabilities and choosing which firms would participate in the joint development and eventually production of equipment for the local market.

This pragmatic approach towards TC development succeeded in achieving a rapid expansion and general upgrading of the TC network. The numbers of telephones and telexes increased dramatically, while the extended and improved transmission infrastructure ensured that almost all of Brazil's regions became integrated within the national communications network. It is the view of the orchestrators of this strategy that the infrastructural improvements could not have been achieved without a corresponding upgrading of the nation's industrial and technological capacity in TCs. At the level of R&D and national and MNC industry, a substantial base in digital technology was created in almost all important areas of peripheral and transmission technology. Even in the highly complex area of public switching the government R&D centre has produced small exchanges suitable for rural TCs, and feels confident that it

can move upwards to medium and large scale public exchanges. The close relationship between the operating companies and the equipment suppliers meant that the upgrading of technological capacity at the industrial level was crucial in supporting the rapidly expanding network.

In terms of establishing a broader base in IT, and in effect using TCs as a cutting edge in digital technology, there are various important achievements and limitations, of direct interest to other DCs. At the level of IT infrastructure there can be little doubt that the upgraded network is well equipped to meet the growing national and international demands for informatics and telematics services. Indeed much of the installed equipment is of later vintage technology than that of developed Europe. Most new exchanges being installed currently employ the latest digital TDS switching, and in this sense Brazil is effectively leap-frogging earlier technology. At the industrial level several of the larger domestic TC firms are currently developing and producing other related IT products such as microcomputers and data transmission equipment, as well as fibre optic systems. The convergence discussed earlier of several information based industries around digital technology has allowed greater scope for diversification by TC firms in Brazil (as elsewhere), and the application of accumulated engineering and management skills to other areas of IT.

Finally at the level of R&D, the government TC development centre has already set up a wide range of digital TC programmes which, potentially, have wider IT application. Substantial experience has been gained in setting up electronic capital equipment and designing various digital products. For instance the first Brazilian integrated circuit suitable for mass production was produced by the centre and a further 4 chips have been successfully developed. These and other achievements such as the development of distributed TDS exchange technology demanded a great deal of expertise in software, CAD, mask production, testing, quality control and in the overall management of information technology. Potentially this substantial base of skills (appx. 800 engineers are employed)

could be used for engineering training in various aspects of IT design, prototype development, management etc. Indeed the centre is already responsible for training of industrial engineers in domestic TC firms, and is participating in the establishment of the new informatics technology centre (CTI). The TC centre is also providing a source of highly trained engineers and specialists for the informatics centre.

Given the tendency towards technological convergence an overall IT or telematics planning administration would probably assist a great deal in exploiting any potential leading edge linkages between TCs and other areas of IT. Most other Latin American countries do not have such institutions or ministries, and TCs are usually organised seperately from other areas of IT especially in R&D and industrial policy.

Also it must be remembered that Brazil is very much a special case in Latin America with an internal TC market greater than two and a half times the size of its nearest rival (Mexico), and many times larger than most of the other nations of the region. Furthermore Brazil has a very well developed university and technological infrastructure to provide the skills and expertise for local industry and research. In discussing other Latin American countries it is therefore imperative to look towards areas of potential regional collaboration, joint development, and specialisation in the development of TC and information technology.

4.2 Mexico

As noted above Mexico is the second largest TC market in Latin America with an estimated equipment sales of $286m in 1985. (Unless otherwise stated sales data are from A.D.Little in constant 1979 prices). The overall operating company, Telemex, has like Brazil taken steps to raise the level

of economic and technological integration of the MNC subsidiaries within the country, in order to help establish a greater indigenous capacity in TCs. Recent government policy has been directed towards assuring Mexican capital participation in the subsidiaries and efforts to increase the nationalisation indices of inputs. The government has also established the long term objective of encouraging greater participation of local industy not only in TCs but in informatics too.

In terms of R&D capacity Mexico has 7 main electronics R&D centres of which the TC centre, Indetelec, is the largest. Together these institutes are involved in several important areas of IT development, including semiconductor design and diffusion, digital TC development and network planning, micro-computer development, computer software, and electronic instrumentation (Galli 1982).

Indetelec was established in 1981 and is a joint venture between Indetel (a former ITT subsidiary, now jointly owned), and Mexican government and private capital. The centre has appx. 275 employees of which 200 are engineers. Technological activities are shared between adaptation of ITTs digital exchange to suit Mexican TC conditions, and increasingly the development of digital transmission and peripheral equipment. Already Indetelec has developed fairly sophisticated software expertise for the exchange system. In addition Indetel overall has achieved high levels of nationalisation of inputs in all but main exchange technology, and subcontracts to around 250 Mexican suppliers.

The second largest MNC supplier, Ericsson, has far less local technological capacity especially in the area of fully digital technology. There is no local technological input to the AXE digital exchange and none planned. All system design and adaptation is carried out almost exclusively in the parent company in Sweden, and local engineering capacity is confined to very low level digital products, and electromechanical crossbar technology.

The different levels of technological integration of the MNCs may reflect the global profit strategies of the

two corporations. Unlike Ericsson, ITT has a strictly decentralised profit cost centre (PCC) strategy which means that each plant must be independently profitable. All inputs including technology, have to be paid for by local subsidiaries and this has led to the building up of local technological capacity in Mexico, as in Brazil. Indeed ITTs Mexican subsidiary does not duplicate technological efforts conducted in other ITT plants abroad and technological developments in Mexico can be exported to other ITT subsidiaries. However, as the Brazilian case illustrated, Ericsson is also willing to transfer greater levels of technology if the necessity arises. There is therefore probably scope for additional local technological activity by Ericsson, if government policy encourages this.

Mexico is also embarking on R&D through a new centre, the National Institute of Communications, under the operating company Telmex. Already Telmex is engaged in the joint manufacture of PABXs with a Canadian firm, and has developed programmes to support the planned network expansion encouraging local firms to paricipate through the use of its purchasing power.

In terms of IT, as Tigre (1983) argues, there is real potential for linking TC activities to the closely related area of telematics. With a coordinated state purchasing policy, and long-term technology strategy, there is scope for entry into IT in such areas as microcomputers, distributed data processing systems, data terminals for videotext, automated office equipment etc. By reserving selected markets for local manufacturers wherever possible and providing support to local industry, Mexico could well enter these areas of IT.

To successfully exploit the existing technological base closer links would also be required between the activities of the research institutes and local industrial requirements. Opportunities in this area will depend very much on Mexico's long-term commitment to local technology.

4.3 Argentina

Like Mexico, Argentina also has a fairly well established university and scientific infrastructure and a large demand for TC equipment, in the region of $162m this year. Argentina's existing electronics industry and internal demand for TCs again offers potential for the broader development of IT. By 1978 Argentina had already established considerable experience in the general field of electronics. At this time the electronics industrial base amounted to over 300 firms employing over 27,000 people, and producing an annual output of over $460 millions (Maxwell 1983). Much of this output is not in digital but analogue technology and includes a substantial proportion of consumer electronics. However, in terms of a technological resource base the electronics sector as a whole employed around 1800 engineers. In addition the Secretariat of Communications coordinates various projects directly concerned with digital technology.

In 1976 the three existing research institutes were amalgamated under an organistation called CENICE, responsible for several development projects in solid state technology (Galli 1983). These projects include the development of hybrid circuits for local TC industrial production, and the design of a limited range of integrated circuits and transistors. The TC sector in Argentina acts then as a source of organisation and financefor digital technological development. Furthermore the rapid forecast growth in TC demand in the region of 7% p.a. over the period 1986 to 1990 means that potentially at least TCs could be a leading source of demand for IT production and development locally.

If we turn to local TC infrastructural organisation the overall operating company Entel is also a source of engineering capacity. Entel employees a total of 45,000 people

responsible for the planning, operation and maintenance of roughly 90% of Argentina's telephone network. There now exists a very substantial unmet demand for TC services and the upgrading of several transmisson network systems needs attending to. Entel has therefore planned major improvements and expansion of the system and digital equipment is expected to be adopted rapidly.

There are three major MNC equipment suppliers, manufacturing and assembling equipment within the country with ITT responsible for 60% of installed facilities, Siemens with 30% and Ericsson with about 10%. Japanese suppliers such as Hitachi are also keen to participate in the market and generally the open market policy has led to increasing competition among the corporations.

Further investigation is required to establish the exact level of technological capacity of the subsidiaries. The ITT subsidiary, CSEA, partly owned by an Argentinian conglomerate, employed a workforce of about 3200 in 1980 and manufactured SXS electromechanical exchanges, PBXs, and a range of other equipment. Siemens assemble exchange equipment mainly from imported components. It appears that little design and development capacity is concentrated in the subsidiaries and additional research is recommended here especially in view of the government's plans for TC expansion and upgrading.

Existing demand from the public TC sector certainly could be employed as a lead in encouraging local industry, and in negotiating for higher levels of technology transfer on the part of the MNCs. Given Argentina's relatively small market, any IT strategy would need to be both selective and probably require government technological and financial support. Maxwell (1983) suggests two possible strategies: first, the support of low volume, small scale, non standardised products engineered for the local market (eg. microcomputers); second, the strategic choice of a small range of high volume, standardised products

or components with a view on export markets. These strategies need not be mutually exclusive but both would require consistency in terms of government support.

A further stategy open to Argentina lies in greater regional cooperation and technology exchange. The country has certainly shown willingness to extend cooperation in TC technology. In 1980 for example, a presidential agreement was signed between the Secretary of State for Communications in Argentina, and the Ministry of Communications in Brazil, covering cooperation in technological and scientific research in TCs. On the broader IT front, Argenina's relatively sophisicated base in numerically controlled machine tools for example (Jacobsson 1983) indicates the possibility not only for exporting to Brazil but also for technology exchange. Conversely Brazil's greater technological capacity in digital TCs provides scope for technology exports and cooperation. Argentina's participation in the 1981 Peruvian scientific and technological cooperation agreement on exchanging expertise and technology, both with Brazil and other Latin American countries, also illustrates the awareness of the benefits to be gained from these types of collaboration.

Ultimately much will depend on any new plans for the expansion and updating of Argentina's TC network by the administration, but potential does exist for TCs to play a leading role as a source of demand, technological expertise, and regional exchanges in technology.

4.4 Venezuela

Although Venezuela boasts one of the highest telephone densities and equipment market sizes in Latin America, the electronics base of the economy is less developed in relation to Brazil, Mexico and Argentina. Venezuela has the highest per capita income in Latin America yet the economic prosperity of the country remains very much based on natural resources and extractive industries, rather than manufacturing production. Although industries such as aluminium, iron and steel, and

refined petroleum have been growing rapidly, natural resource industries such as natural gas, petroleum, hydroelectric power, gold and other minerals are still central to economic output and exports. Manufacturing output however grew very rapidly during the '70s at an average rate of 12% per annum, and by 1980 accounted for roughly 25% of GNP and 20% of the labour force.

Available data for the Venezuelan electronics industry are very sparse and research needs to be carried out to gain a proper appreciation of TC and IT development prospects. However, a recent report concerning the professional electronics industry (Chacon 1984) argues that there are very good prospects in the medium term given appropriate government support. As noted Venezuela is one of the wealthiest Latin American countries. Demand for IT products is high, and in addition, much of the extractive industries are state owned and the government uses revenues to support overall economic development. These factors would suggest that the government could play a dual role in terms of: a) providing a source of demand for output, and b) providing investment and technological support to local industry.

Indeed, as Chacon shows, government demand is already playing an important role in the development of the electronics industry. From a very low base the industry has grown extremely rapidly during the late '70s and early '80s averaging some 45% per annum in terms of sales. Government purchasing played a crucial role in the development of the new firms accounting for between 50% to 100% of demand in the early stages.

At present the microelectronics industrial base is very small with local manufacturers in TCs concentrating largely on electromechanical products and very low level digital equipment. TC output is largely in transmission equipment, voltage regulators and other electromechanical devices. In fully electronic technology production is carried out in modems, PA3Xs, and telex-computer interfacing devices. Interestingly, in the new professional electronics firms overall

42% of those employed are in professional and technologically related areas, of which one third is in R&D. A gradual learning process is occurring in the industry with 30 or so high technology product innovations in production so far.

In the TC sector government demand is often 100% of local firm's total output. Firms are a mixture of local private capital, wholly owned MNC subsidiaries, and joint government/private ventures. In the transmission area output is concentrated in TC cables, in peripheral equipment ouput is largely in PBX (20-200 extensions), together with telephone handsets and teletype terminals. Most public exchange, and digital transmission and telex equipment is imported from the major corporations. The level of locally based technology within the subsidiaries is not clear, neither are government plans towards domestic technology development.

In terms of infrastructure the govenment does plan to introduce digital switching technology, and to install fibre optic PCM transmission. In this manner the new systems will by-pass intermediate technologies and move directly to solid state technology. In view of the large equipment demand by the operating company CANTV, and plans for network expansion there is probably scope for some manufacturing and technological facilities to be located within national boundaries. A detailed assessment would be necessary to evaluate any possibility of linking TC activities to other areas of IT development. Government commitment to long-term technology development would be crucial to any success in the field.

Overall, there does appear to be considerable scope for the larger countries of the region to enter the manufacture and development of IT products. Potentially TCs, as stressed, could play a leading role not only in terms of technological development, but also as a centralised source of demand. When discussing the poorer, and smaller countries of the region it is necessary to look towards possible areas of mutual collaboration to help overcome problems of insufficient scale, poorly developed R&D infra-structure, and the lack of investment resources.

4.5 Other countries of Latin America and possibilities of regional cooperation.

Detailed information on TC and IT developments is extremely limited for the majority of Latin American countries, particularly the smaller economies. There is however evidence that some countries are already entering the manufacture of IT and that TC expansion, as with the larger economies, could play an important role in galvanising local technology and providing a leading source of demand for local production.

Excluding the 4 largest markets, the remaining countries together account for appx. 25% of total Latin American TC sales, around $455 millions in 1985. This constitutes a substantial demand overall and there are also plans in many of the countries to install digital technology. It is important to emphasise that these countries are in no sense an homogenous group, economically, geographically or in terms of telecommunication needs. Equipment demand ranges from Colombia, in the region of $105 millions in 1985 to Bolivia with $15.5m, the Dominican Republic with $9.3m, and other even smaller markets.

Colombia's relatively large TC market and rapid annual growth suggests there is some scope for the manufacture of some TC equipment and possibly some technological development too. Currently most TC equipment is imported from the major European and increasingly, Japanese suppliers. A shift to fully electronic technology is planned over the '80s and the overall TC authority could use its purchasing powers to stimulate local TC and IT production. Indeed there are joint ventures involving government and MNC enterprise in this area and further investigation is recommended to clarify existing plans, and the current level of technological infrastructure. The planned TC expansion in the Amazon region could also be an opportunity for collaboration with Brazilian Ministry of Communications who are also engaged in investments in the Amazon.

Some of the smaller countries already have a surprising level of engineering and technological capacity in electronic technology. Uruguay for instance, has developed

SPC automatic telegraph exchanges and at least three small exchanges (over 100 lines) have been in operation for four years (Telebrasil 1983 Nov/Dec.) These were developed by a local firm in conjuction with the Uruguayan Institute for Electronic Engineering. Another local firm has developed a series of digital products including microcomputers. The quality of these products and prices are internationally competitive and some goods have been exported to Argentina. The relatively low cost of local engineers has proved an advantage. However the very small size of the local market means that specialisation is essential and entry into larger volume production could only be justified on the basis of exports.

Paraguay has 2 main electronics institutes associated with the TC sector. The large demand here for small rural exchanges indicates that Paraguay could potentially benefit from technological cooperation with Brazil, who have both developed and manufactured rural exchanges and are willing to engage in technology sharing arrangements. Costa Rica's rural TC plans could also benefit from Brazil's experience in this area. In the late '70s Costa Rica set up impressive plans for rural TC expansion to serve over 500 local communities but it is not clear how far these plans have progressed, nor whether any local technology development was involved. The local PTT however does organise training abroad for local University engineers and has plans to develop enough technology to adapt systems to suit local circumstances. Costa Rica also has a rapidly growing TC demand and is shifting to fully digital technology.

Peru's TC demand is also rapidly growing and the market, currently standing at over $40m, is expected to double by 1990. At present virtually all equipment is imported but there were plans to set up a TC R&D centre and organise training abroad for local engineers. There is a planned shift to SPC technology and the possibility of local participation in peripheral and perhaps transmission equipment. Currently only cable is being produced locally.

Both the Bolivian and Chilean TC networks have a heavy suppressed demand for services. Both countries have

expansion plans for their TC networks and growth over the period 1985-1990 period is expected to be in the region of 8-10% p.a. in both countries. Some exchange assembly occurs in Chile but both countries rely almost completely on imports of equipment.

Any TC led development of IT will depend very much on the possibilities for regional collaboration, especially for the smaller countries. One of the peculiar characteristics of the TC sector is the close cooperation needed between countries to achieve technical compatability in international communications. Previous experiences of collaboration indicate at least a possibility of extending technological cooperation, and perhaps even reaching agreements on cooperative purchasing and manufacturing specialisation between countries. Here it is only possible to illustrate some examples of the different forms regional cooperation has taken in the past.

At the level of network collaboration there are many examples of international cooperation. In the Central American region CONTELCA, an overall planning body, was established in 1967. Member states included Guatemala, El Salvador, Honduras, Nicaragua and Costa Rica. In 1972 these countries formed INCATEL, the Central American Institute of Telecommunications, to provide training and technical assistance for the member states. During the '70s these organisations achieved several joint objectives including setting up a microwave system to link up the capital cities from Mexico in the north down to Panama in the south. The severe political and military conflict in the area militates against extension into joint planning, purchasing and technological collaboration.

Several projects have been attempted in the Andean sub-region where the principal organisations are CITEL, the Inter-American TC Conference and ASETA, the Association of Telephone Companies of the member countries. These organisations set up microwave links joining up Bolivia, Colombia, Ecuador,

Peru and Venezuela. ASETA also established plans for wider integration through a major satellite programme but this appears to have been abandoned. While these and other examples of collaboration, such as automatic data communications networks, can be presented it must be acknowledged that so far little progress has been made towards technical standardisation, and joint planning and purchasing.

So too in the area of technological cooperation there is far greater scope for technology sharing, trading agreements and specialisation in manufacturing than has so far been achieved. In 1981 a basic scientific and technological cooperation agreement was reached in Peru involving 10 Latin American countries. Brazil has several times expressed a willingness to engage in inter DC technological collaboration and within this agreement Brazil was to send specialists to Honduras to assist in TC development. In several respects Brazil could play a key role in these types of agreements. Brazil has accumulated a considerable experience in developing digital technology locally and adapting systems to suit DC economic and geographical conditions. Brazil probably has more accumulated experience in this field than any other DC and certainly has a considerable advantage over the MNC suppliers in this respect. Overall though, the Peruvian agreement set the guidelines for the lending of technical services and personnel training rather than establishing plans for detailed technological collaboration.

4.6 Summary

Even the smallest DCs need an adequate level of technological capacity to plan, purchase and install TCs efficiently. Capabilities are also required to maintain and expand networks - over reliance on external sources of expertise runs the danger of sub-optimal operating efficiency, costly mistakes, inappropriate purchases etc. In the smaller countries of Latin America it may be necessary to rely predominately on local PTTs to ensure the aquisition of these capabilities. However, given the rapidly growing TC markets

throughout the region, the possibility of international cooperation and specialisation in manufacturing and technological activities should be taken seriously. Any manufacturing investment decision would of course need to take full account of local market size, level of technological infrastructure, optimum production scales of specific product lines etc. (For a full discussion of investment criteria for TCs in DCs see Hobday 1985[A]). There is also the possibility of using TC purchasing demand to stimulate production in other areas of IT, but this would probably require overall IT or Telematics planning at the national level. As yet most countries of the region do not have integrated IT planning bodies and TCs are usually administered seperately.

In the larger countries of the area it may be both feasible and desirable to gain national capacity in TC through more substantial local manufacturing and R&D investment. Indeed this is already occurring in the major countries with PTTs engaging in joint ventures with MNCs, investments in domestic R&D, and the participation of new indigenous firms. One of the key factors in these activities is the centralisation of TC purchasing at the national level. This has enabled the DCs to negotiate more effectively with the MNCs for technology transfer and to foster the development of local industry.

CONCLUSION

Two main conclusions arise from the above discussion: first, that digital technological innovation presents a range of opportunities for market entry in the TC sector; second, there is good reason to believe that Latin America could exploit these opportunites given appropriate government policies. The process of digital technological diffusion has resulted in a dramatic restructuring of the TC industry worldwide. Competition has increased, new competitors have entered and the DCs have become increasingly important as non-committed export markets. At the same time the capital and technological divisibility of digital technology, in contrast to electromechanical, means there is also scope for DCs to enter what was for many years a stable and slow changing oligopoly. Indeed many of the obstacles which prevented DC entry in electromechanical technology are progressively being broken down as the restructuring of the industry proceeds.

Three features of the Latin American market illustrate at least the potential for import substitution in digital TC technology. First, the large and rapidly growing demand throughout the region. Second, the general trend towards the adoption of fully digital equipment. Third, the concentration of TC purchasing power, in most countries, under one central government administration. These features suggest that the possibility exists not only to "leap-frog" older forms of communications infrastructure, but also to exploit the leading edge properties of TCs in gaining a foothold in the broader area of IT in general. In the developed countries this key role of TCs in developing national capabilities is well recognised by governments, some of which are actively supporting their local supply industries in the competition for the rapidly growing IT markets worldwide. In the overall management of the technology gap it is therefore all the more crucial that DCs in Latin America,as elsewhere, respond to these trends and develop policies to prevent exclusion from many information based economic activities.

Telecommunications, of course, are only one of the possible leading edges in the accumulation of microelectronic capacity. Nevertheless TCs are especially important as they represent not only one of the largest sectors in the international economy, but also the very infrastructure for information activities. In fact, as far as infrastructure is concerned, the DCs have an advantage over the developed economies who are generally, heavily committed to less efficient, older vintage technologies. Many of the countries of Latin America are currently building and expanding their basic TC infrastructure, and by directly installing digital systems they are in a position to gain the enormous technological and economic advantages of by-passing earlier forms of infrastructure.

In Part 4 it was suggested that the existing and rapidly growing demand for digital TCs could be used to stimulate local industrial and technological development in many of the countries of Latin America. A surprising level of technology is already embodied in local PTTs, some of which are already engaging in joint manufacturing ventures and R&D investments. However, to exploit the leading edge properties of TCs and establish linkages with other areas of IT production, overall national coordination of IT and telematics activities would probably be necessary. As the technologies in these areas converge, institutional rigidities and divisions may act to prevent possible linkages at the planning, manufacturing and R&D levels. Clearly far more detailed research is required in this area, especially in the assessment of local investment opportunities, but there does appear to be greater scope for Latin American entry into digital TCs. However, as stressed throughout, the exploitation of any opportunities in the area will depend very much on active and well coordinated government policies.

Glossary of technical terms.

ANALOGUE Electro-magnetic wave form used in transmission. Analagous to a continuously variable physical quantity such as temperature. Digital transmission on the other hand is transmitted in discrete, seperate pulses using Pulse Code Modulation(PCM).

COAXIAL A cable used for trunk transmission. The coaxial outer sheath and central coil are both electrical conductors, seperated from each other by an insulating material. Expensive to install in comparison with alternative systems such as microwave relays and fibre optics.

CODEC Coder/decoder. Converts analogue speech into digital form for transmission and back again for reception.

CROSSBAR Near obsolete, electromechanical switching system, used as an intermediate technology between Strowger and fully electronic exchanges.

DIGITAL A discrete or discontinuous signal transmitted in intervals. Most modern TC and computer technology is now based on digital data transmission because of its advantages over analogue, in terms of speed and low cost per bit of information. The terms "digital" and "microelectronic" and sometimes "PCM" are used interchangably to describe modern TC systems.

ELECTROMECHANICAL Semi-electronic, incorporating moving parts unlike solid state microelectronic technology.

HYBRID CIRCUIT A large scale integrated circuit with other miniturised components such as resistors, conductors and capacitors deposited on the same chip.

INFORMATICS Automated digital data processing systems incorporating hardware and software, involving one or more computers. Transmission between computers is normally processed using PCM techniques.

INFORMATION TECHNOLOGY The range of TC, telematics and informatics technologies based upon semiconductor technology, which permit the storage, transmission and manipulation of data in digital form at low cost and great speed. The term is sometimes used to

describe all microelectronic applications and processes Here, however, the term does not include industrial applications of micro technology but is confined to the "information-intensive" industries mentioned above.

INTEGRATED CIRCUIT Also known as a "chip", a microelectronic device, and a semiconductor component. IC's represent the building blocks of the entire microelectronics industry. A ciruit is designed using CAD and a miniturised physical pattern or "mask" is produced, which is then "etched" onto silicon wafers using a complex photo/chemical process. The wafers are then divided up into thousands of individual circuits and mounted onto plastic or ceramic packages and tested. The latest VLSI (very large scale integration) technology allows several hundred thousand circuits to be condensed on one tiny chip.

IT (Information Technology)

MICROELECTRONIC (see integrated circuit and digital).

MICROWAVE Very short electromagnetic radio wave, within the overall wavelength spectrum of long, medium, short, infrared, ultraviolet, X-ray and gamma ray.

MODEM Equipment for modulation and de-modulation of TC signals. In other words it takes an analogue electrical signal and converts it into a digital one for rapid, low cost transmission.

OPTICAL FIBRE Used in PCM transmission, made of silica which is much cheaper and more readily avaible than copper which is used in conventional cables. Advantages over coaxial cable are: larger capacity, resistance to corrosion but not to transmission signals (therefore less signal regenerators or "boosters" needed). In addition fibre optics can be installed using existing infrastructure such as coaxial ducts or railway lines.

PABX Private automatic branch exchange. Self-contained, digital telephone exchanges used by private organisations.

PCM (See pulse code modulation).

PULSE CODE MODULATION Digital transmission of information by modulation of a pulse according to a code.

SEMICONDUCTOR (See integrated circuit).

SOLID STATE No moving parts, fully digital or electronic, as opposed to electromechanical.

STROWGER Electromechanical telephone exchange invented in Kansas in 1889, based on banks of rotary switches connected in series - slow, inflexible and costly in comparison with solid-state systems.

TDM (See time division multiplexing).

TDS (See time division switching).

TELECOMMUNICATIONS Refers to the systems required to produce instantaneous, interactive, communication of information (including speech) across distances. Letter post for example is therefore excluded because it is neither instantaneous nor two-way. Similarly TV and other broadcasting is not included because it is not interactive. The telephone industry accounts for appx. 80% of TC services, while telegraph, telex, and data processing form the large proportion of the balance.

TELEMATICS Also known as teleinformatics. Telematics is based on the fusion of computer and TC technologies made possible by digital technology. Data in digital form is stored, manipulated and transmitted betweencomputers using public TC transmission networks. Telematics also employs broadcasting transmisssion facilities - for example TV sets can be used to access various types of information.(see Videotext).

Time Division Multiplexing A digital transmission mechanism by which many conversations and other signals can be simultaneously transmitted by "interweaving" samples of each signal. Many types of signals can be "multiplexed" together without interfering with each other - unlike unalogue systems.(Also see time division switching)

TIME DIVISION SWITCHING TDS is the most recent stored programme controlled exchange technology. Signals are transferred from one point to another by sending samples down different paths, depending on their desired destination. At exactly the right time

a particular "gate" opens and allows the signals down a specific path. By changing the times at which the gate opens different signals can be accepted. TDS is more economical than conventional space division switching (SDS) where the physical path is permanently connected.

Videotext TV sets are used as data terminals which are connected to the public Telecomms network to receive various kinds of information services.

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Regional Meeting for the Initiation
of a Regional Network for Microelectronics
in the ECLAC Region (REMLAC)*

Caracas, Venezuela, 3-7 June 1985

PROPOSED STRUCTURE OF THE REGIONAL NETWORK FOR MICROELECTRONICS IN THE ECLAC REGION**

a note prepared by the UNIDO secretariat

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* Co-sponsored by SELA/ECLAC.

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The ideas contained in this note on the proposed structure of the Regional Network for Microelectronics*/ in the ECLAC Region (REMLAC) have evolved over a period through: the UNIDO/ECLA Expert Group Meeting on Microeletronics in Latin America in June 1982; exchange of views by UNIDO staff members with policy makers in several countries in the region; the views of a group of three eminent experts who visited Venezuela in November 1983, and elaborated the idea of the network; and the findings of an expert mission which discussed the idea of the network with policy makers in Argentina, Brazil, Mexico and Venezuela. The note incorporates the findings of the experts on an appropriate structure for the network.

Before discussing the proposed structure, it is necessary to take note of the background, in particular the Latin American context and the nature of the microelectronics industry.

Background

The Latin American and Caribbean region accounts for some 50 per cent of the industrial production of the developing countries. Some of the countries in the region have a relatively developed industrial structure and have also started exporting manufactures. The advent of microelectronics is therefore of particular relevance to Latin America and has implications for the development of the region and its competitive ability in international trade. It can be said that the question before the Latin American countries in regard to introduction of microelectronics is not whether they should introduce it but rather how. The UNIDO/ECLA Expert Group Meeting on the Implications of Microelectronics for the ECLA Region, held in June 1982, was decidedly in favour of taking a positive and dynamic approach to the introduction of microelectronics technology in the region within a long-term perspective and based on an integrated strategy which would maximize the potential of microelectronics for unique developing country requirements. The opportunity-cost of not introducing the technology was considered obviously too high.

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*/ As defined, for this purpose, as a broad term to cover developments in computing, systems analysis, telecommunications and microelectronics.

The present state of the electronics industry and the introduction of microelectronics in the region varies as between countries and in regard to the depth of capabilities acquired. One of the earlier introductions ofmicroelectronics was through imports of computers and related systems. It gave rise to problems of excessive imports, underutilization of capacity, maintenance difficulties and lack of software. Based on the experience in this respect, several countries in the region have found it necessary to establish informatics departments or secretariats to regulate the purchases of computers. Some countries, like Brazil and Mexico, have also started production of mini and microcomputers. Applications of microelectronics have been adopted in telecommunications and a number of industries such as petroleum and petrochemicals, chemicals and automotive industries. A number of research groups or centres have been established, though the research pertains more to hybrid circuits than to integrated circuits. Given the dynamic state of the technology and its potentials and implications, obviously far more work has to be done. Recognizing this, the UNIDO/ECLA Expert Group Meeting on Microelectronics recommended the initiation of a Latin American Programme of Co-operation in Microelectronics.

Taking into account the recommendations of the Expert Group Meeting, the continuing interest expressed by several countries in the region for networking and co-operation activities and the urgent need for regional co-operation in this dynamic industrial and technological sector, the time is considered ripe for the establishment of a Regional Network for Microelectronics in the ECLAC region (REMLAC). The substantive elements which should go into the establishment of the network already exist.

The UNIDO/ECLA Meeting spelt out those elements as follows: "The meeting resolved that a Latin American Programme of Co-operation in Microelectronics should be initiated. It recommended that for this purpose UNIDO and ECLA in co-operation with other concerned organizations should elaborate the Programme on the basis of discussions with interested governments and institutions and ascertain their needs and priorities in different sectors. The programme should have regard to co-operation in areas such as early identification and assessment of technological advances in microelectronics; exchange of information and co-operation in regard to public purchases; the establishment or expansion of plants for the design and production of microelectronic components and all interface elements; identification of application

possibilities in critical and priority sectors relating to domestic and external markets, specialized "centres of excellence" to promote and carry outresearch and development and applications including centres in industry or working in close co-operation with industry and networking of such centres; conduct of feasibility studies, training of manpower and reversal of brain drain; socio-economic assessments of the impact of the technology etc. The programme will evaluate and identify formulas for the promotion of R&D with specific relation to mechanisms of public policy. Under the overall programme, several regional co-operative projects in specific subject areas should be elaborated. In addition, interregional possibilities should also be examined and evaluated with a view to establishing co-operation agreements. The Programme should fully take into account existing institutional capabilities and ongoing efforts in the region so as to avoid duplication and enhance its effectivenes". More or less the same activities were also identified as elements of a Latin American Programme of Co-operation which was recommended by the Second Meeting of high-level governmental experts in the field of science and technology, held by the Sistema Economico Latinoamericano (SELA) in May 1984, later supported by the Tenth regular meeting of the Consejo Latinoamericano in October 1984 (Decision No. 200). REMLAC would be the instrument through which the elaboration and implementation of co-operative programmes can be effected.

While the activities indicated in the previous paragraph are in terms of functions, the wide range of microelectronics technology should also be taken into account. The microelectronics technology can be broadly thought of as covering the following areas of specialization:

1. Design and fabrication of IC devices (digitals);
2. Design and fabrication of IC circuits (LSI/VLSI);
3. Design and fabrication of thick- and thin-film hybrids;
4. Design and fabrication of IC microwave devices and circuits;
5. Design and fabrication of opto-electronic devices and circuits; fibre optics and related technology;
6. Power devices, SCR's etc.;
7. Photovoltaic and solar cell technology;
8. CAD for IC and hybrid technologies;

9. Microelectronics applications: customized sub-assemblies and systems; related application and system software generation;
10. Materials technology for microelectronics.

The spectrum of specialized sub-technologies presented above is a design-intensive one. It is also a very capital-intensive technology if one wants to make a significant impact in terms of realizing products, services and applications. It would be unreasonable to expect a single organization or even a single country in the region to be able to master all the facets of this technology. In the context of meeting developing countries' needs this is an ideal technology for promoting horizontal linkages among the developing countries in the region resulting in the creation of a regional network of specialized centres assisting one another with their complementary strengths.

In the Latin American region, it would appear that significant strengths have been built up in one or more of the earlier mentioned facets by at least four countries: Argentina, Brazil, Mexico and Venezuela. Detailed investigations would undoubtedly have to be made to establish in which aspects specific strengths in this technology have been already built up by each country. Brazil seems to have made major investments in mastering facets (1) and (2) and possibly others. In Argentina, too, significant steps seem to have been taken to master IC technology at the pilot plant production level. In microelectronics applications, major efforts seem to have gone into meeting demands in the bioengineering and medical electronics areas. In Mexico considerable emphasis seems to have been placed on microelectronics applications in the communication areas and in software generation.

In Venezuela, the Fundación Instituto de Ingenieria is engaged in a broad range of microelectronics activities centred on the following facets of the technology: hybrid circuits, power devices, fibre optical devices, microelectronics applications in process monitoring and control (especially aluminium industry), applications in data acquisition, monitoring and control of oil production and refining, networking of microprocessors and specialized data-acquisition devices, digital image processing application in the oil industry and other applications in exploiting solar energy. Also in other countries of the Latin American and Caribbean region there are several institutions being active in the microelectronics field and advantages in creating a scientific and technological co-operation among all those centres and organizations are evident.

Structure of the network

The main idea of the network can be summed up in the expression "increase in collective self-reliance". Such a network would link together scientific and technological capabilities, hitherto dispersed, which would find it easier to grow together and to keep in the forefront of international development in this field as well as to render necessary services and introduce innovations in their respective countries.

The essential function of the network will be the establishment of effective mechanisms for flows of information and organization of events among its members which will facilitate the carrying out of co-operative activities and keep its members informed not only of their own activities but also the international trends in this field. It is advantageous that the network does not establish a new secretariat. The nodes which host the periodical meetings of the network could function as its secretariat, as explained later.

Flexibility, structural as well as organizational, is suggested in the creation and operation of the network. It is assumed that any form of co-operation advantageous to the partners may be established within the scope of the network. The co-operation may be bilateral as well as multilateral provided that the information concerning substance of co-operation will be available to all participants of the network and any interested participant may join an already established co-operation arrangement.

It is proposed that REMLAC be organized from June 1985 as a pilot project. It could operate on this basis for six years. After this period a detailed evaluation may be performed and decisions on its future reached. This does not imply that during the operational period no evaluation will be performed. On the contrary, it is expected that all activities of the network will be periodically evaluated at the annual meetings of its participants.

The main elements in the network would be:

1. The objectives pursued by the network members through the functioning of the network. A set of long-term objectives should be carefully spelled out when creating the network and should gain

the agreement of the initial members. It should be possible to modify them when other institutions join the network or when circumstances change. Short-term tactical objectives to guide activities in the network should be adopted at the periodic annual meetings and would normally be expressed in a work programme for the coming period. A separate note is circulated on the work programme of the network. The success of the network will depend on the programme it is able to carry out.

2. The nodes, i.e. the national centres or groups that make up the network. They may assume different characteristics, but in general would have R and D and applications capabilities. The network would accept only one node per country; other local centres should link up through the national node. The nodes would interchange flows of knowledge resources with other nodes. At present there are in Latin America several countries with sufficiently developed centres that may constitute nodes for this network; but there is scope and indeed necessity for each participating country to develop a node. An important function of technical co-operation through the network would be to identify potential nodes in other countries and to help them build up their capabilities so that they can participate fully in the network activities.

   The nodes will formally interact through annual meetings of the network. These meetings may rotate between members of the network who will host such meetings in turn and pay for the travel of the participants. Alternatively, each country may finance the participation of its representative in the network. The annual meetings will elaborate the elements of co-operation and programmes within the network which can then be carried out in a manner agreed upon by the countries participating in each activity. Each node which hosts a meeting of the network may function as the Secretariat till the next meeting.

3. The regional nodes will be formed by national institutions which can function as "regional centres of excellence". Considering the wide range of activities in the field of microelectronics more than

one regional node will be required. In this context and following the offer of the Government of Venezuela, a group of experts evaluated the facilities of the Fundación Instituto de Ingeneria. Through this evaluation the viability of the Fundación to function as a regional node was established and proposals for upgrading its facilities are under consideration. It is hoped that other regional nodes will be identified through the activities of the network.

The group of experts recommended that the Fundación may function as a regional centre of excellence specializing in the following activities of microelectronics technology primarily, taking into accounts its past activities and its future plans:

(i) Design and fabrication of thin and thick-film hybrids;

(ii) Design and fabrication of auto-electronics devices and circuits; fibre optics and related technology;

(iii) Power devices, SCRs, etc.;

(iv) Photovoltaic and solar cell technology; and

(v) Microelectronics applications; customized sub-assemblies and systems; related applications and systems software generation.

It should be noted that the arrangements should be flexible to permit, if necessary, more than one institution to function as a centre of excellence in a given facet of microelectronics technology.

4. The links between the nodes, or channels through which flows would take place. The establishment of stable links is one of the more important tasks which should be undertaken when the network is created. A rapid and easy circulation of flows depends on stable, fluid and reliable links. Other networks have traditionally employed links such as consultation mechanisms, periodic meetings, bulletins etc., in addition to personal contacts of different types. In the case of REMLAC, innovative networking practices could be adopted through the appropriate deployment of the very microelectronics technology that is of central concern to REMLAC.

5. The flows circulating throughout the network between the nodes. Such flows may include the following types of "knowledge resources": (a) knowledge (substantive knowledge on microelectronics and its applications and on related fields; policy knowledge related to the development and use of microelectronics); (b) technology (usually in the form of "packages" or readily applicable solutions that may include design, software etc.); (c) technical and scientific services (analyses, documentation, training, advice on various problems, formulation of projects and programmes); and (d) information (on knowledge resources and on social and economic parameters). Most of these flows will originate within the network, often as a result of joint activities, but there may be significant flows coming from the outside, particularly in relation to a monitoring task which may be shared by the nodes. A particular issue has to do with technology flows insofar as there may be proprietary rights which may impede free transmission to other nodes. This is a point to be considered carefully.

6. The joint activities undertaken by two or more members of the network such as: R and D; training, the establishment of common standards, specifications, procedures, norms and codes, the formulation of common policies, for instance for joint action at the international level. These activities may be designed and carried out as projects, which should be carefully prepared by the participating nodes. Projects will constitute temporary co-operation networks around a single topic, and will generate intense flows between the participants. R and D projects may be of two types. In the first place, they may refer to substantive questions - i.e. to R and D in microelectronics and related topics. Secondly, they may deal with policy issues which need "policy research" of a multidisciplinary nature, possibly with the participation of economists, lawyers and other social scientists. A programme of joint activities is proposed in a separate note.

7. The funding of the activities to be carried out within the network. The importance of this aspect should not be minimized since the smooth and efficient functioning of the network depends

on it. Pluriannual budgets should be prepared and financial resources marshalled; projects and joint activities should not be started if funding is not assured. The main sources of funding would be the participating countries themselves; the UNDP; and various international foundations.

UNIDO as the promoter of the network may provide, within its limited budgetary resources, organizational support for the periodic meetings as well as provision of outside experts on specific topics during the meeting. In addition, UNIDO's support will also be available through regional or national projects for which it will be the executing agency at the request of the countries concerned. At the request of participating governments UNIDO may also provide outside expertise to assist in identifying national centres of excellence.

Ultimately, the REMLAC network should become a true co-operation system. This requires that several conditions be met: clearly defined long-term objectives that are shared by the network members; firm and stable links among the latter; an intense circulation of flows so that through them true systemic relations are established; the carrying out of joint activities with sufficient continuity; and exchanges of flows (mainly information, knowledge and technology) between the nodes and outside institutions in such a way that there is mutual knowledge and a similar approach. If these conditions are obtained and a system is forthcoming rather than a simple network, there will be better possibilities that the efforts and resources assigned to co-operation in REMLAC will produce a higher return through a significant improvement of the efficiency and efficacy of the member institutions.

Action required

Representatives of participating countries are requested to:

(i) consider and agree on the proposed structure of the network;

(ii) indicate the readiness of their countries to participate in the network;

(iii) if possible, indicate a nodal point in the country for the network; and

(iv) indicate activities through which they can contribute to the network or benefit from it.

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Regional Meeting for the Initiation
of a Regional Network for Microelectronics
in the ECLAC Region (REMLAC)*

Caracas, Venezuela, 3-7 June 1985

SOME CONSIDERATIONS ON THE CONTENT AND MODALITIES OF A PROGRAMME OF WORK FOR REMLAC**

a note prepared by the UNIDO secretariat

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The most concrete action of the meeting will be to consider and initiate a programme of work for the network. The value of the network to its participants will depend on the content of its programme and the efficiency of its implementation. This note deals with some general considerations on the network activities, the modalities of developing and implementing a programme and the possible content of such a programme. The ideas developed here are based on the interactions with policy makers and technologists in several countries of the region, the findings of the experts and the recommendations of previous meetings.

General Considerations

The activities of regional co-operation that may be performed as part of the programme of the network should be related to and supported by ongoing national or international activities to the extent possible. In other words, the programme of the network should form part of a total system of activities in the field of microelectronics in the region.

The programme should lend itself to participation by all member countries of the network. This will not, of course, preclude in the programme bilateral and multilateral co-operation among those countries which are interested in a particular activity.

A medium-term programme for six years may be developed but pending its development and funding, interim activities should be commenced without delay. For example, the present meeting itself initiates certain network activities by considering informatics policies, microelectronics-telecommunications interactions, status of R and D and the use of public purchase as an instrument of microelectronics development.

There can be a natural phasing of the activities in that those which will contribute to the strengthening of national actions and national capacities for regional co-operation could be taken up first. In this respect activities such as exchange of experience in policies, exchange of information, strengthening of national focal points, training etc. could be started early.

The activities in the programme of the network could be funded through a combination of different sources such as:

(a) national financing of national activities of relevance to the network including funding of national activities by external funding sources;

(b) national financing of regional activities of the network;

(c) financing of the programme or projects under the programme by funding agencies such as UNDP and others; and

(d) funding of activities by international organizations.

It should be noted, however, that a major source of funding of regional programmes may have to be the funding agencies. Though a few activities could start straight away with a minimum of expense a critical mass of funding should be obtained early in order to secure the success of the network, taking into account the importance of the technology for the region and its rapid development.

The programme could be formulated in a modular fashion, adjustable to present and anticipated resources. While the programme should allow sufficient flexibility and the implementation of several co-operative projects it should not be too diffuse to lack a decisive thrust in certain areas of importance to the region. It should incorporate an element of review and evaluation through periodical meetings of the network.

Contents of the Programme

The co-operative programme of action recommended by the UNIDO/ECLA expert group meeting in June 1982 1/ contains several elements of action which were later supported in similar terms by the SELA expert group meeting 2/, which could form the basis for the range of actions to be undertaken. In addition, the findings of the experts who interacted with policy makers in four Latin American countries need also be taken into account.3/ On this basis the following observations are made on the possible content of the programme of the regional network.

(1) Early identification and assessment of technological advances in microelectronics. This type of activity has also been emphasized by the Fourth General Conference of UNIDO. The UNIDO secretariat has assisted the governments of Mexico and Argentina in considering the establishment of monitoring groups. Such monitoring is also taking place in Brazil and probably in other countries in the region. A network of national monitoring systems could be established to help share the workload and also to develop a regional approach leading eventually to a regional strategy.

(2) Exchange of information and co-operation in regard to public purchases. The meeting has before it a paper relating to the overall concept of public purchasing as an instrument for development of microelectronics.4/ In addition, the papers on the interrelationship between telecommunications and microelectronics provide important ideas in this field. The network's programme could promote exchange of information and experience in this respect and more in-depth national studies to be undertaken by participating countries.

1/ ID/WG.372/17, pp. 6-7.

2/ More or less the same activities were also identified as elements of a Latin American Programme of Co-operation recommended by the Second Meeting of high-level governmental experts in the field of science and technology held by the Sistema Economico Latinoamericano (SELA) in May 1984, later supported by the tenth regular meeting of the Consejo Latinoamericano in October 1984 (Decision no. 200).

3/ Report on the UNIDO Mission Preparatory to the Establishment of a Regional System for Microelectronics in Latin America (REMLAC) (background document).

4/ ID/WG.440/1

(3) Interrelationship between telecommunications and microelectronics. The exploitation of this interrelationship is not only necessary for the successful development of each of the two sectors but can also be used as a tool for their growth. The meeting may consider the type of regional co-operation that could be promoted.

(4) Socio-economic assessment of the impact of the technology. Policy research and impact analysis will have to be encouraged in the participating countries and mechanisms for exchange of information among them promoted. The approach should be to help develop an integrated long-term policy approach to industrial and technological development in the electronics field.

(5) Identification of application possibilities in critical and priority sectors relating to domestic and external markets. Developing and utilizing applications is an important step in the introduction of microelectronics for the socio-economic development of the countries in the region. It may be necessary to launch detailed surveys at the national and regional levels for identification of potential application areas of microelectronics in relation to national and regional needs; promote national interdisciplinary core groups and their interaction at the regional level to promote applications; and promote software houses and system houses at the national and regional levels. It would be desirable to formulate an inventory of the application of devices, equipment, computation tools, specific standards, services and suppliers of microelectronics in order to save time and avoid a duplication of effort in the evaluation of already existing products in the Latin American countries. This inventory might be centralized in one of the countries and could be fed through the evaluations conducted by REMLAC's various institutions.

(6) The establishment or expansion of design centres. As the UNIDO/ECLA meeting stressed, mastery of the technology is not possible without a capacity to develop design and manufacturing capabilities for components. Regional co-operation is possible and indeed necessary in regard to design and fabrication capacity. This could be a major activity for the network. In this context, the UNIDO study on the

establishment of a silicon foundry cum design centre may be referred to 5/. It is possible to establish a series of interlinked national and regional design centres and link them in turn to a silicon foundry preferably to be identified or established in the region.

The UNIDO experts who have had discussions with policy makers and technologists in four Latin American countries in February 1985 have reported that it was generally agreed in the countries visited that the countries participating in REMLAC should formulate a project for the manufacture, at a silicon foundry to be selected, of a multiproject chip. Such a chip would consist of a series of circuits of commercial interest to each country, designed by each of them. Each of the countries would finance its own infrastructure, and a project would be formulated for UNDP or some other international agency for the training and meetings necessary for carrying out the design and for covering the costs involved in disseminating the chip. From the point of view of REMLAC, such a project would be of value, both in strategic and commercial terms, to the countries involved and would result in an installed infrastructure for the production of custom-designed circuits within the region.

(7) Specialized "centres of excellence" to promote and carry out research and development and applictions including centres in industry or working in close co-operation with industry and networking of such centres. As envisaged in the structure of the network, several regional nodes could be thought of which could function as "centres of excellence" in specific facets of microelectronics technology. Reference may be made in this connection to the findings of a group of experts in regard to the potentiality of the Fundacion Instituto de Ingenieria to function as a regional node. Other "centres of excellence" could also be identified. The UNIDO secretariat, on request, may be able to assist the identification of such "centres of excellence" in the region by the provision of a few man-months of consultancy services. An important component of the activities of "centres of excellence" should be the close relationship with industry so as to transfer research results to industry. Policy measures for this purpose may also have to be adopted at the national level in participating countries.

5/ UNIDO/IS.444, "A silicon foundry to service developing countries needs : a preliminary approach".

(8) Conduct of feasibility studies and establishment or expansion of plants for the production of microelectronics components and all interface elements. The conduct of feasibility studies for multinational enterprises in one or more aspects related to microelectronics technology would be an area worth pursuing. This would, however, require the agreement among two or more countries on an integrated strategy for production of microelectronics components. The possibility of formation of subsidiaries by existing Latin American multinational enterprises may also be considered.

(9) Training of manpower and reversal of brain drain. Already there are several formal and informal training courses in which co-operation among Latin American countries is taking place. They will have to be improved and expanded. It is also expected that specialized "centres of excellence" and design centres will incorporate in their activities as an essential element the training of manpower of participating countries. In addition, the necessary machinery should be created for the exchange of teachers, the awards of fellowships and the development of curricula, as well as for regional complementarity in various areas of microelectronics. In particular, it would be useful to design courses for the purpose of creating new groups in those areas of microelectronics not yet represented in every country.

In regard to reversal of brain drain one activity that could be initiated is the compilation of a roster of Latin American experts who would be willing to assist countries in this region by visiting those countries and providing advice, by accepting trainees in their institutions and by working in one of the institutions in the region for a period of time. Each participating country could initiate the preparation of such a roster on a commonly agreed format.

Information should also be developed on the availability of microelectronics experts and consultants, both in the region's research and development institutions and its industry, whose services might be of value to other countries.

(10) Standards, quality control and harmonization. Though the microelectronics industry is still expanding rapidly and no clear picture would appear to have emerged concerning standardization it would be useful to initiate a set of activities for this purpose. It is hoped that this question will be discussed on the basis of detailed information in a future meeting of the network.

It would be desirable if within the region a number of generally accepted standards could be established for both components and equipment. This would lead to greater compatibility of products manufactured by the various sectors of the industry, which in turn would permit the more extensive integration of equipment at the regional level. Moreover, the adoption of common standards would introduce a high level of compatibility for equipment manufactured within the region and greater independence from countries outside the region.

With the possible exception of Brazil, the region lacks extensive experience in quality control techniques and in electronic component and equipment production methodology. There is an evident need to implement a joint project to make it possible, specifically, to draw on the existing experience as a means of learning the various techniques of equipment evaluation and control. The basic idea would be to develop the necessary technology so as to achieve regionally the kind of procedures for test evaluation and standardization that will also satisfy international requirements.

A co-operative effort to introduce unified approach to software development (e.g. identification of UNIX as recommendable software approach) also requires consideration.

(11) Exchange of information. It may be useful to consider mechanisms for such exchange of information including a regional newsletter drawing upon, for example, the UNIDO Microelectronics Monitor.

There must be greater communication between the countries comprising REMLAC and greater publicity of all their activities, both of a commercial nature and in the area of research and development. This will be a very important task for the nodal points of REMLAC. Consideration should also be given to the possibility of creating permanent sections on Latin American activities in already existing journals, such as the Journal de Microelectronica (Brazil), the Revista Telegrafica Electronica (Argentina) and TEC (Venezuela).

REMLAC might also encourage the writing of articles on programmes, actions and achievements in regional microelectronics and promote their distribution to the principal newspapers as a means of generating a greater awareness of this subject.

There is likewise a need to publicize the work being performed by the research and development institutions of the region.

(12) Strengthening negotiating capacities for acquisition of technology. A number of microelectronics products, technology and software are and will continue to be imported by one or more countries in the region. Activities to strengthen negotiating capacities and to exchange experience in this regard are required. Guidelines need to be developed and if possible harmonized in matters such as licensing of software.

(13) Intraregional trade in microelectronics products, equipment and software will have to be promoted and measures for this purpose identified. In this regard there is a need to compile information on existing national capabilities.

(14) As part of network activities advisory services from experts from outside and inside the region will have to be organized to assist national and regional nodes.

(15) Annual or bi-annual meetings of network participants would themselves be an important activity of the network since they will provide an occasion for exchange of information, review and evaluation of the work programme and decisions on future activities. In regard to future network meetings, it is suggested that the country in which the network meeting may be held may finance the travel and per diem of national network participants for that meeting.

It will be seen that the network has a variety of areas and activities to choose from. The priorities and the phasing of the activities have to be decided, keeping in mind the need to achieve a critical mass. Some of the activities such as exchange of information, policy research and monitoring may not require much funding, whereas activities such as upgrading specialized "centres of excellence" will do so. The latter activities as well as those relating to application possibilities and training of manpower would require the identification of high-level specialists within the region.

Modalities

The present meeting should itself enable the formulation of guidelines for the drawing up of a programme for the network and also identify the contents of such a programme in broad terms. A few interim activities should also be identified for immediate implementation.

After the meeting identifies the contents of the programme as indicated above, a small group of experts drawn from the UNIDO, SELA and ECLAC secretariats, combined with any country experts who may wish to participate at their own expense may elaborate a detailed programme in the form of one or more interrelated and consistent projects. In drawing up this programme contacts may be established with policy makers in several countries wherever possible. The programme so elaborated may be submitted to funding agencies, such as UNDP, as may be decided by the meeting.

It is suggested that the drawing up of such a programme and its submission to the funding agencies should be completed by December 1985.

Action by the Meeting

The meeting is requested to consider this note and agree upon (a) the general guidelines for drawing up a programme for the network; and (b) the modalities of preparing the overall programme and several projects within that programme; and identify (c) specific areas of action with which the programme and the projects may concern themselves and (d) possible funding arrangements. Based on the conclusions of the meeting further action could be taken to elaborate the programme in detail with a view to its early implementation.